CLEAN ENERGY MINISTERIAL

Accelerating the Transition to Clean Energy Technologies

Public–Private Consortia for Advanced Clean Energy Technology Research

APPENDIX: Pre-Read for Public–Private Roundtable

Sixth Clean Energy Ministerial

27 May 2015

Mérida, México

INDEX

Goals
Key Questions
Overview
- The Importance of R&D, S&T
- A New Paradigm?
- Global Challenges at Issue
- COP21
- Examples
- International Comparisons

Next Steps/Actionable Items?
Appendix
- Energy Innovation Hubs
- ARPA-E
- Measures of Success
- Suggested Reading

Goals

1. Discuss research and development (R&D) consortia model, share best practices, and learn from international experiences.
2. Identify opportunities for private sector entities and energy ministers to explore new areas of research and ideas to expand the consortia model around the world.
3. Inform the activities of the Clean Energy Ministerial (CEM) initiatives that depend on advanced technology development.
4. Agree on a set of next steps to promote networking amongst stakeholders and promote international scientific consortia.
5. Identify possible pathways for global partnerships and collective investments.

Key Questions

1. What are the key mechanisms and key factors of successful public–private research consortia?
2. How can consortia bring the best minds together?
3. What should be the goals of these consortia?
4. What are the roles of the different stakeholders?
5. What is the right balance between basic R&D and commercialization efforts?
6. How can large-scale, high-impact global programs be funded?
7. How can we try to get measurable outcomes?
8. What are the key actionable items?

Overview

The Importance of R&D, Science & Technology

"Recognition on the part of national leaders that science and technology (S&T) innovation contributes to national competitiveness, improves living standards, and furthers social welfare has driven the rapid growth in R&D in many countries. China and South Korea have catalyzed their domestic R&D by making significant investments in the S&T research enterprise and enhancing S&T training at universities. China tripled its number of researchers between 1995 and 2008, whereas South Korea doubled its number between 1995 and 2006. And there are indications that students from these nations may be finding more opportunities for advanced education in science and employment in their home countries." (NSF press release, 2014)

A New Paradigm?

- The world is more interconnected than ever, and the key challenges such as climate change are global challenges.
- Solutions to these global challenges will likely require scientific and technology breakthroughs (e.g., use technology as a pathway to reduce CO_2).
- Thus the question: Do we need to transition from a *national* innovation paradigm to a *global* innovation paradigm to address the global challenges more effectively?
  - How do R&D and innovation scale on a global platform?
  - How can global R&D strategies be put into practice?
  - How can global efforts be funded?
  - How do we overcome the intellectual property (IP) issues?
- Financing and the involvement of financial institutions are essential to overcome the valleys of death and to bring new technologies to market.

Global Challenges at Issue

Climate Change

Water–Energy Nexus

- ~1.3 billion people have no access to electricity, and an additional 1.2 billion people have no reliable access to electricity (IEA, 2012).
- ~2.8 billion people live in areas with high water stress (WWAP, 2012).
- By 2035, energy consumption will increase by 35% relative to 2010 (350% in Asia, 550% in LatAm, and 700% in Africa), which in turn will increase water needs by 85% relative to 2010 (350% in Asia, 360% in LatAm, and 500% in Africa) (IEA, 2012).

COP21

- Road to Paris (COP21): The UN Member States are negotiating sustainable development goals (SDGs) to be adopted in September 2015.
- SDG priorities include sustainable growth, sustainable infrastructure, and sustainable cities ("smart cities").
- Developing critical "sustainable systems" will require technological breakthroughs.
- R&D centers performing cutting-edge work can accelerate the pace of advanced energy technology innovation.
- A number of disruptive technologies have initially been funded with public investments, e.g., modern medicine, nuclear energy, the internet, wireless communications, GPS, Higgs Boson, etc.

Examples/Models

Several models have been implemented worldwide:

- United States: national labs, Energy Innovation Hubs, U.S. Department of Energy (DOE) initiatives such as Sunshot, ARPA-E
- Germany: Fraunhofer Gesellschatf
- Finland: Sitra, the public innovation fund, supplied early financing for Nokia
- China: The state-owned development bank is offering billions of dollars in loans to some of the country's most innovative companies, including Huawei and Yingli Solar.

INTERNATIONAL COMPARISONS

- The United States differs from many other nations in that there is no central government administration exclusively in charge of research and innovation (Amsden, 1989; Chang, 2008; Mazzucato, 2011). Compared with other nations, basic research in the United States is closely tied to research universities rather than private research institutes.
- OECD performed an international comparison of research funding and impacts (OECD, 2013), finding that the United States still enjoys three distinct advantages:
    1. World class universities
    2. Scale
    3. Being the central node in the global network of science, technology and innovation (STI)

NEXT STEPS/ACTIONABLE ITEMS?

1.
2.
3.

U.S. Examples and Measuring Success

DOE NATIONAL LABS

- The U.S. DOE Office of Science is the lead federal agency supporting fundamental scientific research for energy and the nation's largest supporter of basic research in the physical sciences.
- The Office of Science portfolio has two principal thrusts: direct support of scientific research and direct support of the development, construction, and operation of unique, open-access scientific user facilities.
- With FY 2014 appropriations of $5.13 billion, the Office of Science supports research at DOE laboratories and more than 300 universities and institutions of higher learning nationwide. Together, the 17 DOE national laboratories comprise the federal research system, providing the United States with strategic scientific and technological capabilities. The laboratories:
  - Execute long-term government scientific and technological missions, often with complex security, safety, project management, or other operational challenges
  - Develop unique, often multidisciplinary, scientific capabilities beyond the scope of academic and industrial institutions, to benefit the nation's researchers and national strategic priorities
  - Develop and sustain critical scientific and technical capabilities to which the government requires ensured access

Energy Innovation Hubs

- DOE´s integrated research centers modeled after the Manhattan Project and AT&T Bell Labs look to achieving the U.S. energy goals with science.
- The Energy Hubs have highly integrated teams under one roof, conducting high-risk, high-reward research. The goal is to combine basic and applied research with engineering to accelerate scientific discovery that addresses critical energy issues.
- Universities, national labs, nonprofit organizations, and private firms are eligible to compete for an award to establish and operate a Hub and are encouraged to form partnerships.
- First established in 2010:
  - Consortium for Advanced Simulation of Light Water Reactors: improve nuclear reactors through computer-based modeling
  - Joint Center for Artificial Photosynthesis: advanced research to produce fuels directly from sunlight
  - Joint Center for Energy Storage Research: battery technology for transportation and the grid
  - Critical Materials Institute: develop solutions for rare earth elements and other materials critical to a growing number of clean energy technologies

The SunShot Initiative

- The energy challenges demand that we use an "all-of-the-above" approach that couples our domestic fossil energy resources with renewable sources to achieve sustainable energy independence that lowers costs for consumers. DOE is supporting a range of key activities by private companies, academia, and national laboratories to drive down the installed cost of solar.
- The SunShot Initiative drives research, manufacturing, and market solutions to make the abundant solar energy resources in the United States more affordable and accessible.
- Since the SunShot Initiative was announced in February 2011, the office has funded more than 350 projects in the following areas:
  - Photovoltaics (PV)
  - Concentrating solar power (CSP)
  - Balance of systems costs (soft costs)
  - Systems integration
  - Technology to market
- When the price of solar electricity reaches about $0.06 per kilowatt-hour over its lifetime, it will be cost-competitive with other non-renewable forms of electricity. This in turn will enable solar-generated power to grow from less than 0.05% of the current electricity supply in the United States to roughly 14% by 2030 and 27% by 2050, as projected in the SunShot Vision Study.

ARPA-E

- Advanced Research Projects Agency–Energy (ARPA-E) uses a highly entrepreneurial funding model that supports U.S. energy innovators to explore high-risk, high-reward, potentially transformative technologies that are too risky for industry to fund (long-term social reward, 15–20 years).
- ARPA-E is a catalyst of government–university–industry–national labs partnerships.
- It looks to create technologies that will induce the private sector to scale up those technologies.
- ARPA-E tries to compress the research-to-commercialization process by bringing together scientists, engineers, technologists, and entrepreneurs under one roof.

Measures of Success

What are adequate measures to guide investments in R&D?

- Indicators of human and knowledge capital
- Indicators of the flow of knowledge in specific fields of science
- Indicators with which to track the flow of foreign research talent
- Portfolio analyses of federal research investments by field of science
- International benchmarking of research performance
- Measures of research reproducibility

ARPA-E measures success as follows:

- How many good people and projects are being supported?
- Have small businesses been created from universities?
- How much IP has been created?
- How much money is the private sector investing in the technologies that are emerging from the agency´s efforts?
- How many partnerships among government, industry, and academia have been created?

Suggested Reading

- **The International Energy Agency's "Tracking Clean Energy Progress 2015"** http://www.iea.org/publications/freepublications/publication/Tracking_Clean_Energy_Progress_2015.pdf

- **Rising Above the Gathering Storm** (2007) http://www.sandia.gov/NINE/documents/RisingAbove.pdf

- **Furthering America's Research Enterprise** (2014) http://www.nap.edu/catalog/18804/furthering-americas-research-enterprise

- **Clean Energy Revolution Is Ahead of Schedule,** April 8, 2015, Bloomberg http://www.bloombergview.com/articles/2015-04-08/clean-energy-revolution-is-way-ahead-of-schedule

- **EU (skewed) competitiveness: A different analysis,** May 15, 2014, Mariana Mazzucato: "It is often assumed that there is a finance gap, a credit crunch. Actually, there is plenty of finance, just not enough long-term committed finance. Indeed, across the world the countries that today are leading in terms of smart innovation-led growth are those that have public financial institutions that are providing such long-term finance: Germany's KfW, and China's Development Bank (CDB). Bloomberg New Energy Finance data shows that such development banks are the key investors in the global clean tech landscape." http://www.eutopiamagazine.eu/en/mariana-mazzucato/speakers-corner/eu-skewed-competitiveness#sthash.qflDT5KM.dpuf

- **Startup myths and obsessions,** February 3, 2014, *The Economist*: "Another key element of a healthy *innovation* (not entrepreneurial) ecosystem is the links between different elements of that system. In Germany such links are created by well-funded Fraunhofer Institutes. In Britain these are being imitated through the Catapult centres, which in theory should be linked to Tech City-type projects, either through procurement policy or via learning. Currently there are no links between these. And whereas the Fraunhofer system has an annual research budget of €1.8 billion ($2.4 billion) and a network of 20,000 staff across 60 centres (in 2010), Britain's Catapult centres were given just £200m to spend over 4 years." http://www.economist.com/blogs/schumpeter/2014/02/invitation-mariana-mazzucato?fsrc=scn/tw_ec/startup_myths_and_obsessions

- **[U.S.] Energy Department to Provide $75 Million for 'Fuels from Sunlight' Hub. Center Aims to Produce Liquid Transportation Fuels from Sunlight**, April 28, 2015: "Basic scientific research supported by the Department of Energy is crucial to providing the foundation for innovative technologies and later-stage research to reduce carbon emissions and combat climate change," said Under Secretary for Science and Energy Lynn Orr. "JCAP's work to produce fuels from sunlight and carbon dioxide holds the promise of a potentially revolutionary technology that would put America on the path to a low-carbon economy." http://newscenter.lbl.gov/2015/04/28/energy-department-to-provide-75-million-for-fuels-from-sunlight-hub/

- **If We Dig Out All Our Fossil Fuels, Here's How Hot We Can Expect It to Get**, April 8, 2015, *The New York Times*: There are essentially three long-term solutions to climate change:
  - **Carbon tax:** Put a price on carbon emissions to reflect the damages from climate change.
  - **Cheaper renewables:** Low-carbon energy sources like nuclear, wind and solar to become cheaper than their fossil fuel competition. Long shot without significant public investment in R&D and test deployments of new technologies.
  - **CCS:** Capture & store the carbon before it is released or pull it out of the atmosphere after its release.

  http://www.nytimes.com/2015/04/09/upshot/if-we-dig-out-all-our-fossil-fuels-heres-how-hot-we-can-expect-it-to-get.html?smid=tw-share&_r=0&abt=0002&abg=0

- **Where good technologies come from: Case studies in American innovation,** December 2010, Breakthrough Institute: “Driving directions from your iPhone. The cancer treatments that save countless lives. The seed hybrids that have slashed global hunger. A Skype conversation while flying on a Virgin Airlines jet across the continent in just five hours. Where did these everyday miracles come from? ...the answer is not as simple as Apple, Amgen, or General Electric. We might recall something about microchips and the Space Race, or know that the National Institutes of Health funds research into new drugs and treatments. But most of us remain unaware of the depth and breadth of American government support for technology and innovation. Our gratitude at being able to video chat with our children from halfway around the world (if we feel gratitude at all) is directed at Apple, not the Defense Department. When our mother's Neupogen works to fight her cancer, we thank Amgen, not NIH or NSF.” http://thebreakthrough.org/blog/Case%20Studies%20in%20American%20Innovation%20report.pdf